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The Cost of Developing an Apple Orchard

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OHIO
AGRICULTURAL EXPERIMENT STATION
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Delicious at the beginning of the 15th year, May, 1929.
Left, cover crop plot; right, grass mulch

THE COST OF DEVELOPING AN APPLE ORCHARD

A Record of Costs and Yield Through the First Fifteen Years

C. W. ELLENWOOD

INTRODUCTION

The cost of producing apples, like that of many other agricultural crops, is governed largely by local factors. It is only by the accumulation of much data over a period of years that an accurate estimate of total costs and the relative importance of various items entering into the cost may be made.

The data on cost, as well as yield and grade, presented in this bulletin must be considered as representative of local rather than state wide conditions. Many of the items, however, vary but little from those of the state as a whole; no similar data have been published covering the entire state.

Ballou (3) has published information on the cost of growing apples in a central Ohio orchard, based on a five-year record. Davis (5) discussed the cost of growing an orchard for the first nine years. Hauck (9) has assembled much valuable information concerning number of trees, yield, and price received for apples in the state as a whole. Gossard (8) published data on a ten-year record covering yield, grade, and income from three orchards in various sections of the state with special emphasis on results from various spray formulae. Other data have been published on special economic features of growing apples, but no information has been published in Ohio giving costs for a period of equal length.

THE ORCHARD

The orchard from which most of the data in this bulletin were taken was planted in the spring of 1915. It consisted of 24 two-year-old Stayman and a like number of one-year-old Delicious trees. The trees were set 35 feet by 35 feet and covered 1.35 acres.

The information here submitted tells the story of this orchard from the date of planting thru the fifteenth year. It is a continuation and a more comprehensive report than any heretofore presented (6). The total production of the combined plots or 1.35 acres for the 15 years was 86,395.4 pounds (1,799.9 bushels).

The field in which the trees were set had for many years previously been used for pasture, blue grass predominating. Prior to its use for pasture the field had been in woodland. No chemical fertilizers had been applied to it previous to 1915, but, judged by the amount of pasture produced, it may be assumed the field was in a good state of fertility. The land slopes very gently toward the northeast, tho not enough to induce the soil to wash under normal conditions. The soil is what is known as Wooster silt loam.

The land was not tiled until the fall of 1924. Then, because of the loss of some Stayman trees due to root rot, a line of tile was extended midway between each two rows of trees. The value of the tile was evidenced by a noticeable improvement in the physical condition of the soil, and from the fact that no trees died after the tile was installed.

THE PLANTING PLAN

The orchard was divided into two plots, each consisting of 12 trees of Stayman and 12 of Delicious. In one plot the trees were planted in sod and have continuously been maintained under the grass mulch system of orchard management. The other plot was plowed and has been kept under a system of cover crop management. These are the two methods which have been given most consideration in experimental work in this state. This Station recognizes that apple orchards may be successfully grown under any one of a number of methods of culture.

Many of the commercial orchards of the state are situated on land so hilly as to make any kind of cultivation impossible, and to prevent erosion in such orchards it is necessary to maintain the orchards in sod. The value of mulch in sod orchards, particularly in the conservation of moisture and the accumulation of humus, has often been demonstrated. In recent years the general practice has been to make annual applications of some nitrogen fertilizer to sod orchards. Scarcity of straw for mulching has led some orchardists to use liberal amounts of complete fertilizers or, at least, fertilizers containing phosphorus, over the entire area of the orchards to encourage the growth of grass for use as a mulch, as suggested by the earlier work of Ballou (2). The plan most commonly followed, however, is to mow the orchards twice annually and to leave the grass where it falls. In the more level sections of the state where the orchards may be cultivated the system of management adopted is governed largely by the individual preference of the grower. Sweet clover and alfalfa are being

grown to some extent in orchards and the results obtained in this state as well as in other sections indicate that their use will increase.

THE PURPOSE OF THE ORCHARD

The orchard was planted for a continuation of studies comparing the grass mulch system of orchard management with that of the cover crop system. From the first a detailed and complete account of expenditures has been kept, and a yield record by tree has also been taken annually. It has been hoped thereby to secure some information on the comparative cost of production, the yield record, and net return. Tree measurements indicating the growth made on each plot have been taken several times and are also presented, Table 1. Incidentally, the record of this orchard throws some light on the comparative bearing habits, yield of, and income from Stayman and Delicious, in this particular section during the first 15 years.

TABLE 1.—Showing Growth in Head, Height, and Circumference of Trees

(Orchard planted 1915)

Variety	Plot	Diameter of Head		Height of tree		Circumference of trunk 12 in. from ground		
		1923	1929	1923	1929	1916	1922	1929
		Ft.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*
Stayman	Cover crop	19.32	22.22	15.27	17.95	3.50	16.62	30.41
Stayman	Grass mulch	18.40	20.55	14.70	17.25	3.53	16.41	31.56
Delicious	Cover crop	17.33	23.58	14.33	16.83	3.10	15.64	30.95
Delicious	Grass mulch	16.75	22.98	14.12	17.42	3.04	14.99	30.90

CULTURE METHODS

Grass mulch plot.—The grass on this plot has been mowed at least twice annually. The first mowing is raked and placed in a band under the tree extending outward as far as the limbs extend. Four times during the 15 years it has been necessary to bring in material from outside the orchard to maintain a satisfactory mulch. The amount of mulch used per tree in this plot, approximately 100 pounds of either dry straw or damaged hay, has been practically the same as has been used in an older adjacent orchard (7) which for more than 25 years has been very productive. While nitrogen fertilizers are invariably recommended as supplementary to the grass mulch system of orchard management, good yields were obtained in this orchard as well as in the older one referred to

without the use of fertilizers. In discussing this matter here and elsewhere in this bulletin, the writer does not intend to recommend the use of the grass mulch system in Ohio without the addition of nitrogen fertilizers as a regular orchard practice.

Cover crop plot.—Two cover crops have been grown and turned under annually, soybeans being used as a summer and autumn crop, and rye for winter. The cultivation of the cover crop plot has consisted of an annual plowing in the spring, usually early in May, followed by cultivation until early July at which time the plot was seeded to soybeans. In late September or early October the plot was seeded to rye. For the past three years it has been necessary to cultivate a small area near the base of each tree by hand labor because adequate machinery for this work was not available. This has added slightly, but not materially, to the cost of operations of this plot.

METHODS OF COMPILING COSTS

This orchard of 1.35 acres has been operated as a single unit of the entire acreage of orchard, 40 to 55 acres, at the Ohio Experiment Station. Costs of materials, equipment, and labor are therefore based on costs of similar items prevailing in a commercial orchard of approximately 50 acres. Such overhead costs as the maintenance of water supply, upkeep of buildings, etc., have not been calculated and due allowance for such items should be made. Nor has the tiling done in 1924 and referred to elsewhere been charged against the orchard. No charge is made for the use of horse-drawn implements used in cultivation nor for a wagon. This charge is included under the item of team labor and is discussed elsewhere.

Yield records referred to in Tables 7, 12, and 13 include only those trees which were of the original planting. During the 15 years, seven trees, all Stayman, were replanted. The loss of trees occurred in both plots and, as previously stated, was apparently due to improper drainage. The Stayman trees were especially subject to injury of this nature.

The methods of computing the costs may vary somewhat from the systems used by orchardists and other investigators. It must be kept in mind, however, that local conditions enter into all such calculations.

ITEMS OF COST

Man labor.—Here again the basis of cost represents the top labor wages paid at the Station throughout the 15-year period. These prices are comparable with the average wages paid on the

farms of Wayne County during the same period for skilled farm help. The price per hour increased from 20 cents in 1915 to 40 cents in 1920 and 1921, receding to 33 cents in 1922, increasing to 35 cents in 1923, and remaining stationary until 1928 when it again advanced to 40 cents an hour. The yearly average for the 15-year period was 33.3 cents per hour.

Each item of cost in the orchard from those requiring the most skill, such as spraying and pruning, to the more common labor of hand cultivation and mulching are based on the same average hourly wage.

Team labor.—The motive power used in the orchard has been either a team or a single horse. While the horses used have been the property of the Department of Horticulture and it has not been necessary actually to hire any team work, the prevailing price of team labor in the community has been used as a basis for calculation. The yearly average rate per hour for a team for the 15-year period was 32.9 cents. The use of a wagon is customarily included in the rate of pay used for team labor.

No charge has been made for the use of any horse-drawn tool except for a sprayer. The investment of any tool used in cultivation would not exceed the cost of a wagon.

Trees and planting.—This item of cost, Tables 12 and 13, represents the actual cash expenditure for trees. While this price is somewhat lower than the prevailing price of trees in 1915 it must be remembered that the selling price of nursery stock was less then than it is now. The first cost of the tree, however, is of minor importance when compared with development costs.

The cost of planting represents the actual labor involved in staking the ground, digging the holes, and planting the trees.

Hand labor.—This includes all hand work, such as hoeing around the trees and removing litter from the bases of the trees, not covered in the other items of costs.

Pruning and disposal of brush.—Included under this head is the labor cost of pruning, together with hauling the brush out of the orchard and burning it. The brush is removed from the orchard by wagon. The orchard is so located that it is necessary to haul the brush a distance not exceeding 200 yards. A short haul is an important item in the economic disposition of brush.

The pruning given the trees is of the type recommended by the Ohio Experiment Station. In the earlier years of the orchard the pruning was very light, although some was done each year, except in 1918. This early pruning consisted merely of tree training.

Since the trees reached bearing age, heavier pruning has been the rule. The practice during the last four years has been to remove considerably more brush, through the elimination of many of the lower branches which were no longer productive and through more thinning out of small branches throughout the tree to promote vigor and aid in coloring the fruit. While this type of pruning is in conformity with good commercial practice, it will be seen that the cost of pruning has increased with the change from light to moderate pruning coincident with heavy production. In the few instances where limbs more than 1½ inches in diameter have been

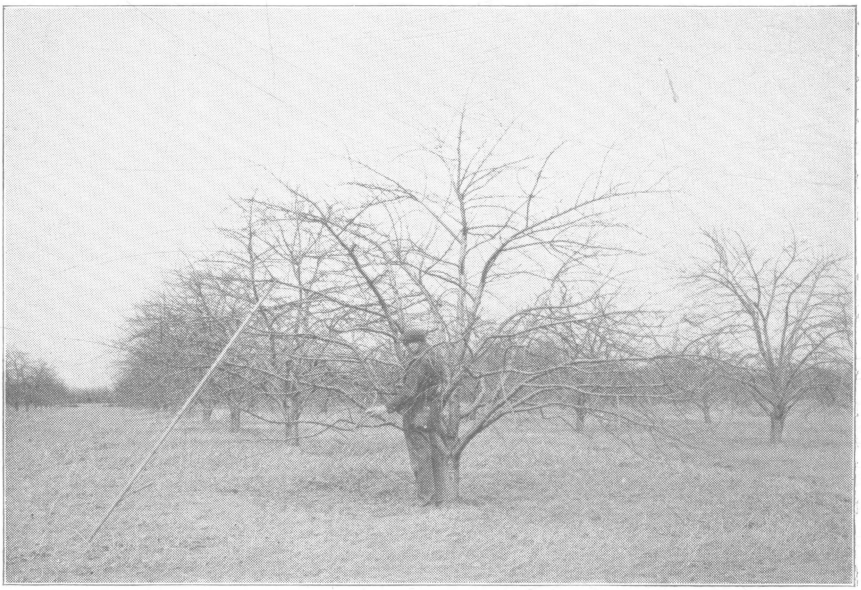

Fig. 1.—A typical 14-year-old Delicious tree. Modified central leader head

removed the wound has been covered with lead paint. The tree shown in Figure 1 is typical of the form of the trees. While the two varieties vary somewhat in habit of growth, the Delicious having a tendency to be more upright than the Stayman at first, an attempt has been made to develop both varieties into modified leader trees. The result has been that at the end of the 15 years the Delicious trees averaged 7.6 main scaffold limbs per tree and the Stayman, 7.5. This fact, coupled with the uniformity of size of tree as shown in Table 1, indicates approximately equal possible bearing surfaces on the two varieties.

Tree guards.—To prevent rodent injury, a cylindrical guard was placed about each tree at the beginning of the second year. This guard was made from galvanized wire netting, four mesh per square inch, cut into strips 18 inches by 18 inches. The guards were adjusted in the spring and in the fall of each year, to avoid the possibility of girdling, but aside from this they were not taken from the trees until the trees were ten years old.

Mulch.—The trees in the grass mulch plot were mulched each year except in 1918 when the grass was left in the orchard without being raked up. In 1922, 1925, 1927, and 1928, mulch from outside the orchard was added. The cost involved by this, together with the cost of labor required in placing the mulch about the trees whether grown in the orchard or brought in from outside, is included in the item of cost of mulch in Table 13. In the first year the trees in both plots received a mulch of manure.

Fig. 2.—Orchard during the fourth growing season. Left, Cover crop plot before being seeded; right, Grass mulch plot

In the past seven years, covering the period both plots produced crops above the cost of production, the cost of mulch and the application of the mulch for the period was $2.35 per tree. The cultivation and cover crop seed used on the cover crop plot cost $3.24 per tree for the same period.

In years when it was necessary to apply straw from outside the orchard at the rate of 100 pounds per tree, the straw costing as much as $10 per ton, the cost of mulching equalled or exceeded the cost of cultivation and cover crop seed. In 1925, 1927, and 1928 when straw was added to the trees in the grass mulch plot, the cost per tree for mulching for the three-year period was $1.98, which may be contrasted with $1.92 for cultivation and seed on the cover crop plot for the same period.

While, as a matter of fact, additional mulch has been brought into this orchard from outside four times in the past eight years, or on an average of once in 2 years, in the older orchard previously referred to (7), the trees have actually been mulched in this way only once in three or four years. This statement is made as an explanation of what may seem a heavy expenditure for mulch.

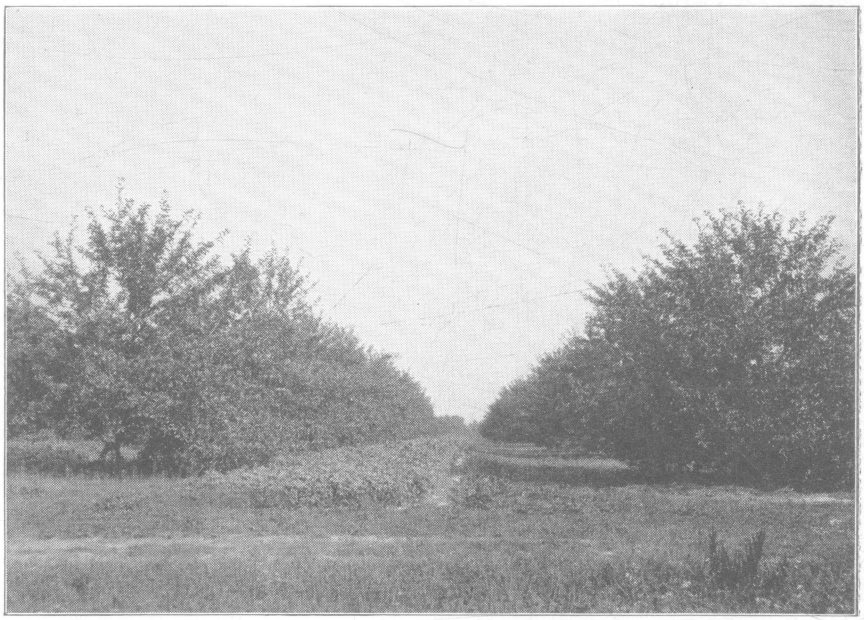

Fig. 3.—11 years from planting. Left, Cover crop plot—Soybeans; right, Grass mulch plot

Unless there is material suitable for mulching available on the farm it would seem that the economic thing to do would be to increase the production of mulch grown in the orchard by the use of fertilizers, as has already been suggested. It may be well to state here that a blue grass sod may in some instances, following the use of large amounts of fertilizers for several years, become too

thick and result in the grass consuming the fertilizer at the expense of the trees. This is what is termed a sod-bound condition and is corrected by breaking up the sod and cultivating the orchard for a few years. This condition is not apt to prevail in an orchard where a heavy mulch is maintained around the tree, as this keeps the grass killed out.

Cover crop seed.—The cost of the cover crop seed represents the actual cost per tree at the current value of such seed from year to year. Soybeans were used generally at the rate of 1½ bushel per acre, and rye at the same rate.

Spraying.—The cost of spraying was the highest single item of expense. The number of applications made each year depended upon seasonal conditions and ranged from a single application from the second to fifth year to as many as seven applications in 1928. Since the trees have been fruiting freely, six applications annually have been the general rule. Included in the cost of spraying are the cost of materials, labor, and machine. The cost of materials is based on current prices available to orchardists for orchards of commercial size. Labor costs were computed at the rate shown in Tables 12 and 13. The machinery used in spraying was a hand pump during the first few years, and a power sprayer subsequently. During the five years, 1925 to 1929, the same sprayer was used throughout and records of costs were kept in all the orchards at the Station during that period. Interest and depreciation on the sprayer, gas and oil for operation, and repairs made the cost of operating the sprayer 67 cents per hour, which, together with the cost of labor, team, and materials, comprised the total cost.

The program followed varied somewhat to meet the special requirements of any given season, but in the main consisted of either a dormant spray of oil or lime sulfur, followed by two pre-bloom sprays of lime sulfur, and 3 after-bloom sprays of lime sulfur, dilute strength, plus arsenate of lead. When required, nicotine sulfate was used; this was necessary about once each season. The amount of material used per application on each tree in the 5-year period ranged from 6.5 gallons in 1925 to 14.1 gallons in 1929, or an average of 9.9 gallons for the five years, per application, for each tree.

During the five years, 1925-1929, the average annual cost per tree was $1.29 or practically 18 cents per bushel of fruit. The amount of material used per tree on the two plots was so nearly equal each year that the cost of spraying each plot is here shown to be the same. Weather conditions, as well as the amount of disease

or of insects present, influenced the amount of material as well as the kind of material used. A summary of the amount of solution used per tree together with the cost for the past five years is presented in Table 2.

TABLE 2.—Spray Material and Cost per Tree for the 5-year Period, 1925-1929

(Orchard planted 1915)

Year	Total amount per tree per season	Total cost per tree
	Gal.	*Dol.*
1925	38.8	.961
1926	43.0	.798
1927	70.2	1.621
1928	61.7	1.193
1929	85.0	1.871
Average	59.7	1.289

Fertilizers.—For the first 8 years no fertilizers were used. In the spring of 1923 one fourth of each plot was fertilized with nitrate of soda at the rate of 2 pounds per tree; at the same time a like number of trees were fertilized with sulfate of ammonia used at a rate equivalent in units of nitrogen to 2 pounds of nitrate of soda. This plan has been followed annually since 1923, increasing the amount of nitrate of soda to 4 pounds per tree in 1925 and the sulfate of ammonia proportionately. One half of the orchard has remained unfertilized throughout the 15 years.

The fertilizer was applied broadcast by hand each year about the time growth was starting. It was scattered from the outer extremities of the branches to within 30 inches of the trunk. The amount of fertilizer used was governed largely by the customary recommendation to use one-fourth pound of nitrate of soda per tree for each year of the tree's age, or an equivalent amount of sulfate of ammonia.

Since the studies in this orchard are related only incidentally to fertilizers, no special importance has been attached to this factor. The data in Table 3 show the yield record of fertilized and unfertilized Delicious trees in each plot. Delicious was used as a basis of comparison because of the complete stand of original trees in each plot. It will be noted that there is no indication as yet that fertilizers have increased the yield. While the total production on the grass mulch plot has been a little greater where the trees have been fertilized, the opposite is true on the cover crop plot.

In Tables 12 and 13, showing the comparative cost of production on each plot as a whole, the cost of fertilizer per tree was

assessed against the whole number of trees on each plot rather than against those actually fertilized. This correction was made to permit a comparison of the average tree in each plot without consideration of fertilizer treatment. The cost of fertilizer per tree on each plot was the same since the treatment was identical.

TABLE 3.—Effect of Fertilizer on the Average Production per Tree for the 7-year Period, 1923-1929

(Orchard planted 1915)

Variety	Plot	Treatment	Average total yield per tree
			Lb.
Delicious	Cover crop	Not fertilized	1691.1
Delicious	Cover crop	Fertilized	1529.6
Delicious	Grass mulch	Not fertilized	1246.5
Delicious	Grass mulch	Fertilized	1282.1

The fact that no increase in yield is shown from the use of fertilizers in this orchard should not be construed as indicating that such results may be expected to be duplicated generally, nor, in fact, to mean that this condition will continue in this orchard. In practically every experiment or demonstration undertaken in the state nitrogen fertilizers have increased the yields in orchards grown in grass, and often in cultivated orchards.

Interest and Taxes.—Since no actual record of the cost of this item is available the figures used in these calculations are based on what seemed to be reasonable assumptions. The valuation placed on the land was $125 per acre, which represented a good price for land adjacent to the Experiment Station in 1915. This price has fluctuated somewhat since then but remains a fair valuation for similar land. The interest on the land is therefore calculated at the rate of 6 per cent on an assumed cost of $125 per acre. The taxes are based on the rate of taxation of the township in which the orchard is located, which ranged from $7.20 in 1915 to $13.20 in 1929 per $1000 of valuation. These figures, however, in no case allow for special tax assessments. The valuation per acre for purposes of taxation was increased year by year and represents a liberal estimate of the probable tax valuation.

Interest at 6 per cent has also been charged on the capital necessary for operation until the income from the fruit had exceeded the cost of production, and had theoretically paid off such indebtedness. It should be understood that the figures used as cost under this item are assumed and not actual, and are not intended as a rule for estimating this item of cost generally.

Thinning.—Regular thinning was practiced for only three years. In 1927, 1928, and 1929 the fruit was thinned to a good commercial distance, leaving the apples spaced 8 to 10 inches between growing points. In 1929 the thinning was confined almost entirely to Stayman. While the two varieties in this orchard require less thinning than some other varieties, it has been found advantageous in recent years to do a limited amount of it. No propping of limbs was done, although a few trees were braced with wire cable. The cost of thinning represents the actual cost of labor.

Picking.—Picking costs are based on the labor charge for this work. The fruit was picked at approximately the following rate per man: trees bearing light crops, 4 bushels per hour, and those bearing medium crops, 5 bushels per hour. Either baskets or picking bags, to suit the convenience of the picker, were used. In either case the apples were emptied into bushel crates. Step ladders and convenient fruit ladders were available at all times. While the product from each tree was weighed in the orchard, no charge was made for the labor involved in this work.

Hauling apples to storage.—The charge for this item consists of labor charge for a team and wagon and for 2 men. The orchard is so located that 50 bushels per hour was about the average amount which could be hauled to the storage house by such a crew.

Rental on crates and small tools.—Since this block of trees was being operated as a unit of a larger orchard, it has seemed best to make a rental charge for the use of crates and such small tools as pruning shears, saws, ladders, hoes, thinning shears, forks, picking baskets, and picking bags. Hence the amount shown under this account represents the proportionate share of the expense of such items for the entire acreage of orchard under operation.

Because much of the fruit was sold soon after grading, the buyer providing his own container, the turnover of the crop in this manner permitted the use of each crate at least twice during each season, thus reducing the charge per bushel for rental. The charge per bushel of fruit for crate rental averaged 2 cents. The rental charge for small tools assessed against each plot was 25 cents for the first 6 years and 75 cents per plot after that.

Grading.—The type of mechanical grader used had an average capacity of 80 bushels per hour. The grader was driven by a small electric motor. The cost of operating this grader, together with the accessory conveyors, allowing for interest on investment,

depreciation, repairs, and electric current, was estimated at 1 cent per bushel. In addition to this charge the labor of eight men required to operate the grader was included in this item.

The apples were divided into four grades annually. The following standard of size and quality was followed closely. The No. 1 grade were the apples which were above 2¾ inches in diameter, and which would otherwise meet the requirements of U. S. Fancy. The No. 2 grade included those fruits 2¼-2¾ inches in diameter, which would otherwise meet the standards of U. S. No. 1. The No. 3 grade consisted of apples above 2¾ inches but slightly off color, windfalls, bruised specimens, and fruits showing slight defects. The culls were the smaller apples, defective fruits, and badly bruised or dirty specimens, and these were sold for cider. Table 4 show the percentage of the various grades for a 9-year period.

TABLE 4.—Comparison of Grades of Apples Produced Under the Cover Crop and Grass Mulch Systems, 1921-1929

(Orchard planted 1915)

	No. 1 Per cent	No. 2 Per cent	No. 3 Per cent	Culls Per cent
Cover crop plot				
Stayman	76.0	17.0	2.9	4.1
Delicious	72.8	20.5	2.1	4.6
Grass mulch crop				
Stayman	75.3	17.1	3.3	4.3
Delicious	72.5	20.6	2.3	4.6

No detailed record of color of fruit was made until 1929, but it is worth noting that it was good each year. In Table 5 is presented the color grade of Stayman for 1929, which fairly represents the average color of that variety for the period. Data available on color of Delicious were more meager but indicated it to be equal to that of Stayman.

TABLE 5.—Color Grade of Stayman Apples Based on the 1929 Fruit Crop

Plot	Above 33% Over color	15 to 33% Over color	Below 15% Over color
	Pct.	*Pct.*	*Pct.*
Cover crop	84.93	12.99	2.08
Grass mulch	84.46	12.54	3.00

Supervision.—Since all charges in the several items involving the use of labor were based on the actual price paid for labor in any given year, and did not take into account supervision, a separate item is included to cover this charge. This charge is based on the proportionate share of time of the foreman of the Station orchards and gardens which was given over to this orchard. Expressed in another way, it allowed for ½ of one per cent of a foreman's time during the first three years, gradually increasing to one per cent of his time during the last six years. Such supervision was intended to involve the laying out of the orchard, the purchase of materials, and the general oversight of all orchard operations, including picking, grading, and sales. It was recognized that any figures used as a means of calculating cost of supervision were local in their application and more or less arbitrary. For these reasons we desire to caution against a too literal application of this item.

TABLE 6.—Comparative Costs of Supervision of Cherry Orchard in Michigan and Apple Orchard in Wooster

Age of orchard	Year	Cherry orchard in Michigan* 8th thru 15 th year	Year	Supervision charge apple orchard in Wooster 8th thru 15th year
		Per acre		*Per acre*
8	1917	$15.51	1922	$11.06
9	1918	17.80	1923	12.07
10	1919	17.80	1924	12.07
11	1920	17.80	1925	16.10
12	1921	17.80	1926	16.10
13	1922	17.80	1927	16.10
14	1923	14.50	1928	16.87
15	1924	14.50	1929	16.87

*Rogers, A. J. Jr. Studies in Orchard Management with Special Reference to Cherry Production. Mich. Agr. Exp. Sta. Spec. Bull. 166, p. 10, 1927.

The cost of supervision per acre ranged from $16.00 in 1915 to $16.87 in 1929. Covering the period from the 8th to the 15th years inclusive the cost for supervision increased from $11.06 per acre to $16.87. Compared with these figures, Rogers (12) found, as shown in Table 6, the cost of supervising a cherry orchard in Michigan from its 8th to its 15th years inclusive ranged from $14.50 to $17.80 per acre. While the period over which Rogers compiled this data extended from 1917 to 1924, the wage scale at Wooster was but slightly higher between 1922 and 1929 than it was from 1917 to 1924.

RELATIVE IMPORTANCE OF ITEMS OF COST

During the first eight years (1915-22) on the cover crop plot, interest and taxes constituted the largest item of expense. Ranked next, in order of importance. came supervision, team labor, cover

crop seed, and spraying. On the grass mulch plot interest and taxes was also the largest item of expense, followed by supervision, spraying, mulch, and team labor.

TABLE 7.—Cost per Bushel of Producing Stayman and Delicious Apples, Including Growing, Picking, and Grading

(Orchard planted 1915)

Costs	Cover crop plot							Av. annual cost for 7 years	Per cent of total cost
	1923	1924	1925	1926	1927	1928	1929		
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	
Pruning and disposing of brush	.045	.020	.016	.021	.038	.084	.052	.039	4.9
Spraying	.312	.216	.141	.067	.159	.293	.271	.209	26.1
Fertilizer	.021	.012	.006	.004	.005	.015	.009	.010	1.2
Cultivation (hand and team)	.114	.083	.042	.017	.021	.294	.102	.096	12.0
Cover crop seed	.047	.044	.032	.010	.010	.024	.018	.026	3.2
Interest and taxes	.489	.287	.135	.040	.027	.069	.042	.156	19.5
Thinning	.....	.....	.....	.....	.049	.049	.016	.016	2.0
Picking	.088	.070	.058	.058	.058	.100	.074	.072	9.0
Rental on small tools and crates	.038	.030	.025	.023	.023	.029	.025	.028	3.5
Hauling of apples to storage	.021	.021	.021	.021	.021	.023	.023	.022	2.7
Grading	.045	.045	.045	.045	.045	.050	.050	.046	5.7
Supervision	.170	.098	.062	.036	.041	.104	.061	.082	10.2
Total cost per bushel	1.390	.926	.583	.342	.497	1.134	.743	.802	100.0

During the period 1923-29 Tables 7 and 8 show that spraying was the largest item of expense in the cost of production per bushel in both plots. On the cover crop plot during this 7-year period 26.1 per cent of the cost of producing a bushel of fruit was spent for spraying, 19.5 per cent for interest and taxes, 12 per cent for cultivation, 10.2 per cent for supervision, and 9 per cent for picking. "Spraying" as used here includes labor, materials, and equipment. The division of these items under spraying varied

TABLE 8.—Cost per Bushel of Producing Stayman and Delicious Apples, Including Growing, Picking, and Grading

Costs	Grass mulch plot							Av. annual cost for 7 years	Per cent of total cost
	1923	1924	1925	1926	1927	1928	1929		
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	
Pruning and disposing of brush	.032	.028	.020	.027	.047	.110	.057	.046	5.7
Spraying	.209	.350	.170	.090	.207	.351	.320	.242	29.8
Fertilizer	.014	.020	.007	.006	.006	.018	.011	.012	1.5
Mowing (team and hand)	.040	.069	.058	.012	.039	.085	.020	.048	5.9
Mulch	.....	.....	.080	.....	.045	.103	.....	.032	3.9
Interest and taxes	.268	.384	.134	.054	.037	.091	.054	.146	18.0
Thinning	.....	.....	.....	.....	.063	.056	.022	.020	2.5
Picking	.087	.087	.070	.058	.058	.100	.075	.076	9.3
Rental on small tools and crates	.034	.040	.027	.024	.025	.031	.027	.030	3.7
Hauling of apples to storage	.021	.021	.021	.021	.021	.023	.023	.022	2.7
Grading	.045	.045	.045	.045	.045	.050	.050	.046	5.7
Supervision	.114	.161	.075	.048	.054	.124	.072	.092	11.3
Total cost per bushel	.864	1.205	.707	.385	.647	1.142	.731	.812	100.0

with material used and price of labor, but was approximately 48 per cent for materials, 28 per cent for man labor, 8 per cent for horse labor, and 16 per cent for equipment. On the grass mulch section the cost of spraying represented 29.8 per cent of the total cost, interest and taxes 18 per cent, supervision 11.3 per cent, mowing and mulch 9.8 per cent, and picking 9.3 per cent. Pruning costs were exceeded on each plot by grading costs as well as the items already mentioned above.

While interest and taxes was the largest item of expense in the pre-bearing stage of the orchard it ranked second from 1923 to 1929. Heavy production will tend to reduce further the relative importance of this item.

Scoville (13) in a survey of a number of orchards in Western New York found labor to be the highest item of expense, taxes and interest ranked second, while spraying ranked third. In his calculations all items of labor were grouped under one head. Merchant (11) in a survey of Maine orchards reported human labor as representing 35.09 per cent of the total cost of production, interest and taxes as 16.61 per cent, and spray materials as 4.8 per cent. Here again all items of man labor were grouped under the head of human labor. Merchant also found the three-year average man labor cost of harvesting the fruit to be divided as follows: 64.80 per cent for picking, 26.20 per cent for grading and packing, and 9 per cent for hauling. This ratio of distribution of hand labor costs during the harvesting very closely approximated the costs of these items at Wooster.

In the discussion of costs in this bulletin, man labor has been included along with other charges involved in the several orchard operations. However, since hand labor constituted a major portion of a number of the items, if assembled under one head, it would be the largest item of cost.

SPECIAL ITEMS OF COST

Packing and storage.—As previously stated, the apples from this orchard were sold or given over to experimental work so soon after grading that no storage charge was made. Since the selling price of the fruit has in no case included package, no charge was made for this item. Due weight should be given this fact in considering the income from this orchard.

Loss of trees during 15-year period.—As stated elsewhere, seven of the original Stayman trees had to be replaced during the 15-year period. So far as could be ascertained the loss of the trees

in every case was traceable to improper tile drainage. The amount of replacements made in this block is believed to be greater than would usually be necessary. Investigations conducted by the U. S. Department of Agriculture and reported in Technical Bulletin 54, December 1927 (14), reported an average loss of 9.8 per cent of original trees in the Cumberland-Shenandoah section. The trees included in the study were mostly under 25 years of age.

PLOTS COMPARED

Reference to Table 9 will show that up to and including the ninth year, 1922, the grass mulch plot consistently produced more fruit than the cover crop section, indicating a tendency towards earlier bearing on the grass mulch than on the cover crop plot. However, when the yield record for the first 15 years is considered, there is a decided margin in favor of the cover crop plot in the case of both varieties. During the early years, cost of production was lower on the grass mulch plot, but, with increased yields on the cover crop section, the conditions have been reversed. Not only was the yield higher on the cover crop plot but the cost of production per bushel was generally less. The fruit harvested on the grass mulch plot the ninth year was the first crop which exceeded in value the cost of production. But it was not until the tenth year that the value of the fruit from the cover crop plot was above the cost of production. In each succeeding year both plots yielded crops whose value exceeded the cost of production. Had the Delicious been as productive in the early years as the Stayman, profitable production would have been reached two years earlier.

At the end of the 15 years the average Stayman tree on the cover crop plot had produced a total of 205.7 pounds more than the Stayman on the grass mulch plot. The difference was even more pronounced in the case of Delicious, where the average tree on the cover crop plot had a total production of 344.2 pounds more than the average production for the trees in grass mulch.

Reference to Table 4 will show how remarkably close the grades have been on the two plots.

Color has generally been high on both varieties in each plot. The color grade shown in Table 5 is the record for the 1929 crop of Stayman. It will be seen that there is no significant difference in the color of the fruit of this variety from the two plots. The interesting fact about the color grade is the amount of highly colored fruit in each plot.

TABLE 9.—Comparative Average Yield per Tree of Stayman and Delicious Varieties of Apples

(Orchard planted 1915)

Variety	Plot	1921	1922	1923	1924	1925	1926	1927	1928	1929	Total
		Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Stayman	Cover crop	42.7	87.5	128.1	245.1	317.6	713.1	528.6	285.3	563.0	2911.0
Stayman	Grass mulch	43.8	90.3	248.0	182.8	309.9	677.9	329.7	248.6	574.3	2705.3
Stayman	Average	43.2	88.9	188.1	213.9	313.7	695.5	429.2	267.0	568.7	2808.2
Delicious	Cover crop	.....	14.2	57.0	76.9	334.2	426.0	458.3	120.6	137.3	1624.6
Delicious	Grass mulch	.....	15.0	66.8	42.7	248.3	281.5	402.2	113.1	109.7	1280.4
Delicious	Average	.....	14.6	61.9	59.9	291.3	353.8	430.3	116.9	123.5	1452.5

When the size of the trees is considered, Table 1, there is no great difference apparent in the two plots. In fact, the only significant difference at the end of the 15 years appears in the record of yield.

Although it has sometimes been suggested that trees grown under the grass mulch system tend to bloom later than trees under tillage, this was not true in this orchard. The average date of full bloom over the 9-year period, 1921-29, was exactly the same on each plot. The average date of full bloom for Stayman was May 8 and for Delicious May 7, nor was there any appreciable difference in the date of picking.

Fig. 4.—At the end of 15 years. Left, Cover crop plot; right, Grass mulch plot

Bachtell (1) reported more net income during the first 15 years from the cultivated than the grass mulch section of an orchard located on the Hamilton County Experiment Farm.

Ballou (4) reported that over a 7-year period in a young orchard located on the Clermont County Experiment Farm the average production per tree was slightly higher on the grass mulch section. The fertilizer treatment in both the Hamilton and Clermont County orchards was similar to that in the orchard at Wooster and consisted of three different treatments; unfertilized, nitrate

of soda, and sulfate of ammonia. All of these orchards were so located that cultivation was possible without serious loss from erosion.

Experience in Ohio has shown that good yields may be expected from either the orchard which is regularly cultivated and in which cover crops are grown, or from the orchard which is grown on sod and to which fertilizer is regularly applied. The labor involved and the cost of operating the orchard under the cover crop system will generally be found greater than it is in the sod orchard.

Other items worthy of thought in considering the method of culture to be followed are the working conditions in the orchard. During wet weather it is much easier to get heavy equipment through the sod orchard than the cultivated.

Windfalls from the sod orchard are more salable than those from the cultivated orchard. On the other hand, certain insects, as, for instance, the apple flea weevil, are easier to control in the cultivated orchard. The hazard of rodent injury is also less in the cultivated orchard.

YIELDS AND INCOME

The average yield per tree shown in Table 12 and 13 is the average weight of apples per tree, based on both varieties in each plot. Where the term bushel is used, it represents 48 pounds.

Only those trees of the original planting which were standing at the end of the 15 years were used in obtaining the average production, value per tree, and cost per bushel as shown in Tables 12 and 13. The actual production of the entire 1.35 acres (48 trees) for the 15 years was 86,395.4 pounds, having a valuation of $3043.85. The value of the Stayman was $1806.45 and the Delicious $1237.40. The total amount expended in the orchard during the 15 years was $1633.10. This total production includes the yields of all the original trees together with the yields from the seven replants of Stayman.

Notwithstanding there have been no replants required in the case of Delicious, the total yield of Stayman has exceeded the total yield of Delicious on each plot in every year except two. Thus it will be seen, both from the standpoint of yield and income, Stayman has surpassed Delicious in spite of the fact that the loss of trees has been confined to Stayman. In this connection it is well to state that at Wooster, Stayman has consistently reached heavy production before Delicious. In fact, Delicious has only rarely reached profitable production within 10 years from planting. On lighter

soils Delicious tends to come into bearing younger. It should also be stated that the yields of Stayman in the Station orchard, judged by observations of growers in other sections of the state, are somewhat above the average for this variety for the state as a whole.

The orchard is so located that ample opportunity for cross pollination is afforded and yields have not been adversely affected by this factor. In two or three years late spring frosts have killed some of the buds, but in only one year (1929) was the total yield influenced by frost. It is obvious from the total yield that the orchard could be rated as productive. The prices received for the apples are shown in Table 10. These do not include package or delivery charge.

TABLE 10.—Prices per Bushel Received for Apples at Wooster, 1921-1929

(Bushel=48 pounds)

Variety	Grade	1921	1922	1923	1924	1925	1926	1927	1928	1929	Average
		Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*
Stayman	No. 1	1.75	1.75	1.50	2.00	1.75	1.35	2.00	2.00	2.50	1.84
Stayman	No. 2	1.00	1.25	1.00	1.50	1.25	.85	1.25	1.50	2.00	1.29
Stayman	No. 3	....	.75	.....	1.00	.....	.....	.75	1.00	1.25	.95
Stayman	Culls	.40	.40	.50	.50	.35	.35	.35	.50	.70	.45
Delicious	No. 1	.....	1.75	1.50	2.00	2.00	1.50	2.00	2.00	2.75	1.94
Delicious	No. 2	.....	1.25	1.00	1.50	1.50	1.00	1.25	1.50	1.75	1.34
Delicious	No. 3	.....	.75	.....	1.00	.....	.....	.75	1.00	....	.88
Delicious	Culls	.....	.40	.50	.50	.35	.35	.35	.50	.70	.46

The two varieties represented in this orchard generally command good prices on the market where they are sold. In fact, Delicious usually sells for more than any other variety. While the prices shown in Table 10 represented the actual prices received, they were no doubt higher than the average for the state. Thus due weight should be given to these prices in any consideration of the income. In Table 11 will be found a schedule of selling prices of apples during November as reported by Hauck (9) for the state as a whole, over a 5-year period, 1922-26. These prices presumably include the package and refer to the average of all varieties. Compared with this are the average prices received for No. 1 and No. 2 grades of Stayman and Delicious at Wooster, package not included. It is assumed that the fruit sold in the No. 1 and No. 2 grades would be similar in quality to the grade of fruit referred to by Hauck. The average price for the State, as shown by this table, is $1.20 all varieties considered; for Stayman at Wooster, package not included, $1.42 and for Delicious $1.50. The average price received for the apples since the orchard came into bearing, all grades considered, has been a trifle above 3.5 cents per pound.

TABLE 11.—Prices per Bushel Received for Apples at Wooster Compared with State Average

Year	Average farm prices per bushel in Ohio in November	Average farm prices per bushel at Wooster for No. 1 and No. 2 grades†	
	All varieties*	Stayman	Delicious
	Dol.	*Dol.*	*Dol.*
1922	1.35	1.50	1.50
1923	1.08	1.25	1.25
1924	1.25	1.75	1.75
1925	1.40	1.50	1.75
1926	.90	1.10	1.25
Average	1.20	1.42	1.50

*Hauck, C. W. The Apple Industry of Ohio. Ohio Agr. Exp. Sta. Bull. 418, 1928.
†Bushel=48 pounds.

It must be borne in mind that this selling price is considerably above the level of the state and this fact, coupled with good yields, has unquestionably lifted the income per tree from this orchard much above the average. However, it may fairly be said that the orchard has been given no unusual treatment, nor has it responded in a phenomenal manner. Having good elevation, the damage from spring frosts has no doubt been less than in orchards not so favorably located; this has been a factor in the fairly regular production, and serves to emphasize the value of regular bearing in the income from an orchard over a long period of years. The income for the orchard has been affected by the high percentage of fruit in the first grade and low percentage in the cull grade. The record covers the period when the orchard was at an age when highest quality fruit could be expected, but probably not the period of the most economical production. The cost of production for the 15-year period, taking the orchard as a whole and considering replants, was a trifle less than 2 cents per pound. The average cost of production per year for a 5-year period, 1924-28, as reported by Ballou (3) was 69.84 cents per bushel, including package. The orchard where the data were taken was under the grass mulch system of management, the trees ranging from 12 to 35 years in age. In the grass mulch plot as shown in Table 8 the average cost of production per year for the 5-year period, 1925-29, was 72.2 cents per bushel (48 pounds), not including the package. The cost of package would increase the cost of production 15 to 18 cents per basket. However, in making comparisons it is but fair to emphasize that the bushel referred to here is 48 pounds, whereas the content of the bushel basket is about 6 pounds less, depending

Charts showing the relation between cost per bushel and yield per tree. Straight line fitted by method of least squares.*

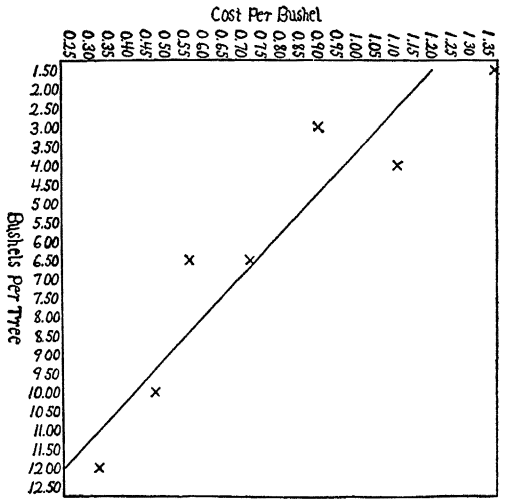

Chart 1.—Cover Crop Plot

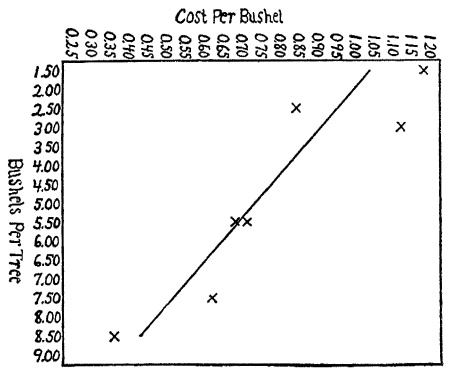

Chart 2.—Grass Mulch plot

*Credit is due G. H. Stringfield for preparation of the charts.

TABLE 12.—15-year Record of Production Costs per Tree of Stayman and Delicious Apples, 1915-1929
Cover Crop Plot

Costs	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*
Man labor per hour	.20	.20	.25	.30	.36	.40	.40	.33	.35	.35	.35	.35	.35	.40	.40
Team labor per hour	.20	.20	.30	.30	.36	.40	.40	.33	.35	.35	.35	.35	.35	.35	.35
Tree	.100														
Planting tree	.033														
Cultivation, man and team	.223	.154	.333	.167	.262	.274	.400	.219	.213	.252	.289	.198	.213	.588	.603
Miscellaneous hand labor	.025	.162	.026					.048		.015				.609	.104
Pruning and disposing of brush		.004	.005		.022	.025	.038	.038	.084	.061	.106	.243	.388	.343	.357
Tree guards		.100													
Cover crop seed	.164	.062	.042	.083	.135	.052	.146	.083	.087	.141	.217	.120	.098	.098	.124
Number of spray applications		1	1	1	1	2	5	5	6	6	6	5	7	6	6
Spraying: including labor, machine, and material		.022	.018	.028	.062	.175	.182	.209	.580	.690	.961	.798	1.621	1.193	1.871
Fertilizer and application									.039	.039	.039	.050	.050	.062	.062
Interest and taxes	.288	.352	.414	.478	.540	.635	.744	.810	.910	.919	.916	.462	.277	.282	.290
Thinning													.502	.200	.113
Picking							.040	.082	.163	.224	.397	.676	.596	.407	.511
Hauling to storage							.010	.020	.039	.067	.143	.244	.214	.094	.159
Rental of small tools and crates	.010	.010	.010	.010	.010	.010	.042	.054	.071	.098	.170	.266	.238	.116	.172
Grading							.020	.043	.084	.144	.306	.522	.460	.204	.344
Supervision	.169	.169	.169	.194	.194	.194	.316	.316	.316	.316	.422	.422	.422	.422	.422
Total cost per tree	1.012	1.035	1.017	.960	1.225	1.365	1.938	1.922	2.586	2.966	3.966	4.001	5.079	4.618	5.132
Average yield per tree in pounds							19.4	47.5	89.3	153.4	326.7	556.5	490.3	195.5	330.8
Value of fruit per tree							.594	1.489	2.425	5.808	11.560	14.591	17.404	7.450	16.86
Cost of production, per bushel (48 lb.)							4.795	1.942	1.392	.926	.581	.345	.499	1.133	.744

TABLE 13.—15-year Record of Production Costs per Tree of Stayman and Delicious Apples, 1915-1929
Grass Mulch Plot

Costs	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*
Man labor per hour	.20	.20	.25	.30	.36	.40	.40	.33	.35	.35	.35	.35	.35	.40	.40
Team labor per hour	.20	.20	.30	.30	.36	.40	.40	.33	.35	.35	.35	.35	.35	.35	.35
Tree	.100														
Planting tree	.050														
Mowing, man and team	.025	.033	.063	.017	.054	.092	.042	.065	.080	.068	.064	.075	.076	.085	.050
Miscellaneous hand labor	.021	.046	.016	.040	.008	.058	.008	.041	.000	.044	.024	.016	.040	.038	.033
Pruning and disposing of brush		.008	.005		.022	.025	.038	.038	.088	.056	.115	.239	.366	.376	.335
Tree guards		.100													
Mulch and application	.049	.017	.031		.023	.033	.033	.375	.032	.024	.693	.016	.541	.516	.033
Number of spray applications		1	1	1	1	2	5	5	6	6	6	5	7	6	6
Spraying, including labor, machine, and material		.022	.018	.027	.062	.175	.182	.209	.580	.690	.961	.798	1.621	1.193	1.871
Fertilizer and application									.039	.039	.039	.050	.050	.062	.062
Interest and taxes	.289	.352	.415	.415	.478	.548	.620	.685	.746	.756	.754	.484	.290	.308	.318
Thinning													.490	.189	.130
Picking							.035	.073	.243	.172	.395	.519	.456	.339	.438
Hauling to storage							.008	.016	.058	.041	.118	.187	.164	.078	.135
Rental of crates and small tools	.010	.010	.010	.010	.010	.010	.046	.057	.095	.079	.153	.217	.196	.107	.156
Grading							.017	.038	.125	.088	.254	.400	.352	.169	.293
Supervision	.169	.169	.169	.194	.194	.194	.316	.316	.316	.316	.422	.422	.422	.422	.422
Total cost per tree	.713	.757	.727	.703	.851	1.135	1.345	1.913	2.402	2.373	3.992	3.423	5.064	3.882	4.276
Average yield per tree in pounds							16.8	42.8	133.6	94.4	271.0	427.5	375.5	163.0	280.8
Value of fruit per tree							.515	1.338	3.630	3.575	9.614	11.216	13.233	6.207	14.257
Cost of production, per bushel (48 lb.)							3.843	2.146	.863	1.207	.707	.384	.647	1.143	.731

upon variety and size of fruit. Upon a pound basis, the cost of production at Wooster has been but a trifle more than that reported by Ballou (3).

Johnson (10) in a survey embracing a large number of orchards in the Yakima valley, Washington, reported the average cost of producing a box of apples, plus packing, in 1926 was $1.03 and $1.14 in 1927. In the Wenatchee Valley section the same survey showed the production costs slightly higher than in the Yakima Valley.

There are no data available to show at what age an orchard may be expected to produce fruit most economically. Maximum production is not reached with most varieties until the trees are 30 years or more of age. It seems quite evident that a 15-year old tree has not quite reached the age when the lowest cost of production may be expected.

SUMMARY AND CONCLUSIONS

An analysis of the cost of developing an apple orchard of Stayman and Delicious trees through the first fifteen years is presented. Two systems of culture, the grass mulch and the cover crop, are compared. This study yielded the following information:

The cost of production under both systems of management for the 15-year period was a trifle less than two cents per pound.

The average cost of production per bushel (48 lb.), excluding the package, for the seven-year period, 1923-29, was 80.2 cents on the cover crop plot and 81.2 cents on the grass mulch plot.

Spraying represented the largest item of cost per bushel, with interest and taxes ranking second.

Stayman came into profitable production much earlier than Delicious and in the first 15 years yielded much more fruit per tree.

Delicious proved more resistant to root rot, due to improper soil drainage than did Stayman.

The trees on the grass mulch plot came into bearing earlier than those on the cover crop plot. Income first exceeded cost of production on the grass mulch plot during the ninth year and on the cover crop plot during the tenth year.

At the end of 15 years there was no significant difference in the size of the trees on the two plots.

The total yield of fruit was higher and the cost of production per pound lower on the cover crop plot than on the grass mulch plot.

The method of culture had no effect on the average date of full bloom, nor on the color of fruit.

The cover crop plan of management can be used safely only on level or nearly level land.

Maximum economy in the grass mulch system is attained only by the use of inexpensive mulch material or by growing the mulch in the orchard.

The grass mulch system must be supplemented by the use of nitrogenous fertilizers. The addition of phosphorus is regularly recommended to promote growth of mulching material.

High quality fruit and regular and heavy production were as important in economic production in this orchard as cost of operation.

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